INTERCOMPARISON AND SELECTION OF RAINFALL ESTIMATION AND NOWCASTING ALGORITHMS BY THE GOES-R ALGORITHM WORKING GROUP

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Background / Objective

Hydrology Application Team (AT) Background

- Support the AWG by providing recommended, demonstrated, and validated algorithms for processing GOES_R observations into user-required products which satisfy requirements.
- Each Application Team will:
  - Review candidate algorithms and identify algorithm deficiencies;
  - Establish priorities and suggest solutions to resolve deficiencies;
  - Formulate, oversee, and participate in algorithm intercomparisons;
  - Recommend algorithms for GOES-R.
- The selected algorithms will then be demonstrated and documented for delivery to the System Prime via the GOES-R Program Office.

Hydrology AT Members

- Bob Kuligowski, NESDIS/STAR, Chair
- Ralph Ferraro, NESDIS/STAR
- Kuo-lin Hsu, UC-Irvine
- George Huffman, NASA-GSFC (SSAI)
- John Janowiak, UMCP/ESSIC
- Matthew Sapiano, UMCP/ESSIC

Hydrology AT Environmental Data Records (EDR's)

- 3.4.6.1, "Probability of Rainfall" (0-3 h)
- 3.4.6.2, "Rainfall Potential" (0-3 h)
- 3.4.6.3, "Rainfall Rate / QPE"

Objective

- Select algorithms that will form the basis of the Hydrology EDR's in the GOES-R Ground System:
  - Rainfall rate retrieval;
  - Nowcasts of reflectances and brightness temperatures, which will be processed by the rainfall retrieval algorithm to form the basis for the Rainfall Potential and Probability of Rainfall EDR's.

Candidate Algorithms and Validation Data Sets

Candidate Nowcasting Algorithms

- Hydro-Nowcaster (HN; Scofield et al. 2004) computes displacement vectors via correlation matching; applies statistically-optimized growth / decay parameters
  - Also a variant (HNsd) that rescales nowcasts to preserve the variance of the initial observations.
- K-Means (Lakshmanan et al. 2003)—uses hierarchical K-means clustering to identify features and motion vectors at multiple scales; simple growth / decay based on temperature changes.
- Thunderstorm Initiation, Tracking, and Nowcasting (TITAN; Dixon and Wiener 1993)—identifies contiguous cloud features and weighted centroids and tracks / extrapolates motion.
  - Also a variant (TITANgd) that extrapolates growth / decay with time.
- McGill Algorithm for Precipitation Nowcasting by Lagrangian Extrapolation (MAPLE; Turner et al. 2004)—uses a variational scheme for echo tracking, wavelet filters to estimate predictability at each scale, and semi-Lagrangian advection.

Candidate QPE Algorithms

- QMORPH (Joyce et al. 2004a)—extrapolates the most recent MW rain rates forward in time using IR-derived motion vectors.
- CPC-IRFREQ (Joyce et al. 2004b)—matches the cumulative distributions of IR brightness temperatures with MW rainfall rates at 8-km resolution to fill in gaps in MW imagery
- CMORPHIR—hybrid of QMORPH and CPC-IRFREQ that chooses one or the other based on proximity in space to MW data (closer favors QMORPH; farther away favors CPC-IRFREQ)
- NRL-Blended (Turk et al. 2003)—matches the cumulative distributions of IR brightness temperatures with MW rain rates at the MW footprint resolution.
- PERSIANN (Sorooshian et al. 2000)—uses artificial neural networks to match radiance values and spatial textures with MW rain rates.
- SCaMPR (Kuligowski 2002)—uses discriminant analysis and regression to relate radiance values to MW rain rates.

Proxy and Ground Validation Data

- METEOSAT Second Generation (MSG) Spinning Enhanced Visible and InfraRed Imager (SEVIRI) data were used as ABI proxy channels
- Rainfall round validation data include:
  - ~16,000 **daily** rain gauges over the SEVIRI full disk obtained from CPC;
  - ~1,125 **daily** gauges and ~65 **hourly** gauges from the British Atmospheric Data Center (BADC) MIDAS data;
  - ~12 **10-min** gauges on floating buoys from the Pilot Research Moored Array in the Atlantic (PIRATA).
- Nowcast validation used the corresponding SEVIRI data as ground truth.

Methodology and Sample Results

Candidate Algorithm Evaluation

- Algorithm developers used SEVIRI data from 1-5 January, April, July, and October 2005 to adapt their algorithms for ABI capabilities.
- SEVIRI data from the 6th through the 9th of each month were used to create independent estimates for evaluation by the Hydrology AT.
- The Hydrology AT evaluated the algorithms against the corresponding gauge (rain rate) or SEVIRI (nowcasts) data over selected regions to reduce data volume.

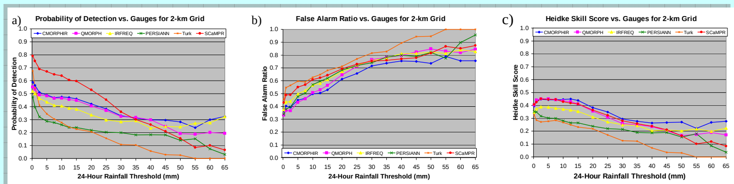

Figure 1. Binary scores: (a) probability of detection; (b) false alarm ratio; and (c) Heidke Skill Score as a function of observed 24-h CPC gauge rainfall accumulation.

a)	RMSE (mm)	Volume Bias	CC	b)	RMSE (mm)	Volume Bias	CC	c)	RMSE (mm)	Volume Bias	CC
CMORPHIR	**7.248**	**0.940**	0.559	CMORPHIR	0.838	0.175	0.144	CMORPHIR	1.066	**1.039**	0.078
QMORPH	7.785	0.938	0.520	QMORPH	0.832	0.152	0.168	QMORPH	1.349	1.771	0.075
CPC-IRFREQ	8.188	0.935	0.481	CPC-IRFREQ	0.852	0.218	0.112	CPC-IRFREQ	0.938	0.718	0.055
PERSIANN	7.728	0.613	0.409	PERSIANN	**0.826**	0.146	**0.174**	PERSIANN	**0.806**	0.204	0.051
NRL-Turk	7.772	0.825	0.351	NRL-Turk	3.130	2.734	0.098	NRL-Turk	1.428	2.045	**0.305**
SCaMPR	7.506	1.437	**0.566**	SCaMPR	0.861	**0.511**	0.136	SCaMPR	0.866	0.837	0.141

Table 1. Rainfall estimates sampled onto a 2-km grid versus (a) 24-h CPC gauges; (b) 1-h MIDAS gauges; (c) 10-min PIRATA gauges. Statistics are Root Mean Squared Error (RMSE), volume bias ratio, and correlation coefficient (CC).

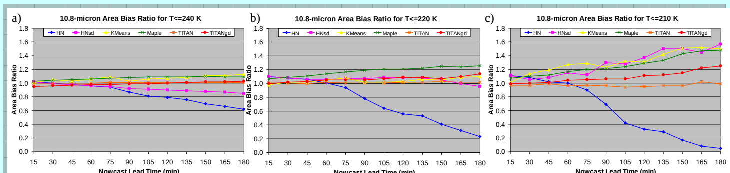

Figure 2. Area bias ratio as a function of nowcast lead time for IR window (10.8-µm) temperatures below (a) 240 K; (b) 220 K; and (c) 210 K.

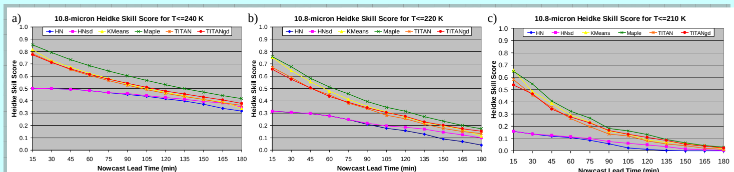

Figure 3. Heidke Skill Score as a function of nowcast lead time for IR window (10.8-µm) brightness temperatures below (a) 240 K; (b) 220 K; and (c) 210 K.

Conclusions

Rain Rate

- The CMORPHIR algorithm performed best overall, followed by QMORPH and SCaMPR.
- However, the developers elected not to participate in operational implementation, so SCaMPR will be used in the demonstration GOES-R Ground System.

Nowcasts

- The MAPLE algorithm performed best overall, followed by K-Means and TITANgd.
- However, the final selection has not yet been made because licensing issues with several candidate algorithms are still being resolved.

DISCLAIMER: The contents of this poster are solely the opinions of the author and do not constitute a statement of policy, decision, or position on behalf of the GOES-R Program Office, NOAA, or the U.S. Government.

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